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SMALL AIRCRAFT CRASHWORTHINESS

VOLUME II

REFERENCE DATA BASE, PROGRAM AND USER GUIDE

Prepared for
Transportation Development Centre
by
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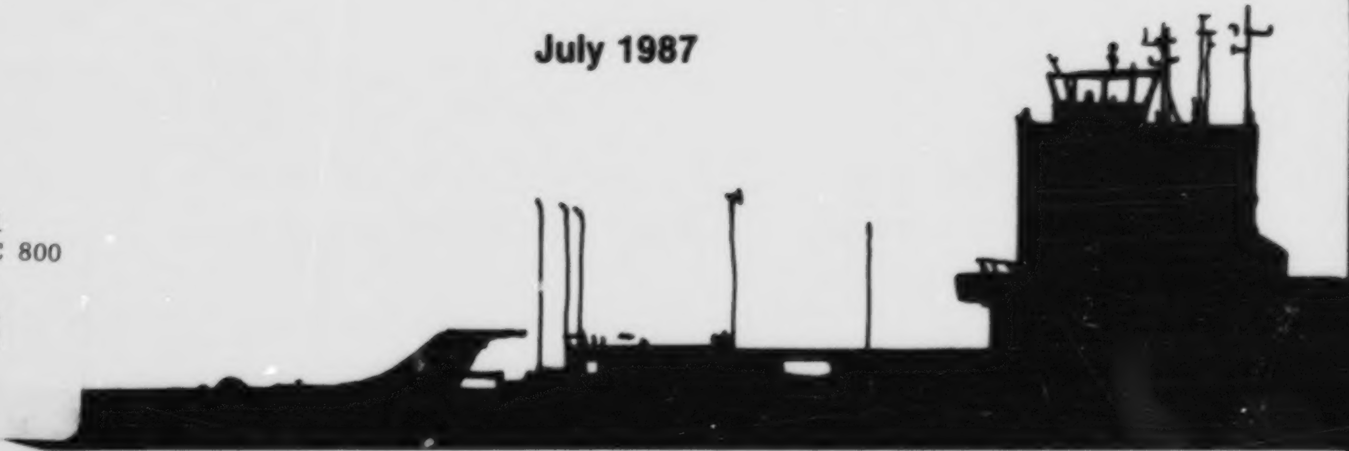

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By

Robin Lee Monroe
SYPHER:MUELLER International Inc.

Walter McLeish
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Un sommaire en français de ce rapport est inclus avant la Table des matières.

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17. Abstract

Volume I of this study reviews past accident investigations, regulatory developments and crashworthiness research activities for small aircraft in Canada and the United States. From this analysis and extensive interviews, "gaps" or areas where further research and development would be beneficial are identified. A proposed R&D program, which would contribute to the enhancement of the safety of small aircraft and which would be seen to comprise a meaningful Canadian contribution to joint aeronautical research and development efforts between the United States and Canada, is outlined.

Volume II of this report comprises a bibliographic data base on small aircraft crashworthiness, incorporating over 1300 references, and a user guide. The data base program is totally menu driven and allows specific references to be extracted by keyword.

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Volume I: An Overview of North American Research and Development
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17. Résumé

Le tome I du rapport de recherche sur la résistance à l'écrasement des petits avions au Canada et aux Etats-Unis traite des enquêtes antérieures sur les accidents, ainsi que de l'évolution de la réglementation applicable et des travaux de R&D réalisés dans ce domaine. Cette analyse et des entrevues exhaustives ont permis de mettre en évidence des lacunes et de cerner les secteurs où l'accroissement de la R&D serait bénéfique. Ce rapport propose un programme de R&D débouchant sur une sécurité accrue des petits avions et qui constituerait une participation intéressante du Canada aux efforts déployés dans ce domaine des deux côtés de la frontière.

Le tome II du rapport renferme un recueil de données sur la résistance à l'écrasement des petits avions, comportant plus de 1 300 références, ainsi qu'un guide des utilisateurs. Ce recueil se présente sous la forme d'un programme informatique dont l'exploitation est facilitée grâce à un menu d'interrogation, et la récupération des données accélérée par l'utilisation de mots clés.

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SMALL AIRCRAFT CRASHWORTHINESS

AN OVERVIEW OF NORTH AMERICAN RESEARCH AND DEVELOPMENT

EXECUTIVE SUMMARY

Prior to 1970, no mechanism existed to coordinate aeronautical research and development (R&D) between Canada and the United States. This resulted in a certain amount of duplication and an absence of sharing in areas of common interest.

To address this situation, the Volpe-Jamieson agreement between the Federal Aviation Administration (FAA) and Transport Canada was signed in 1970. The purpose of this agreement was to allow for the joint identification of areas where each country excelled or had the potential to excel in particular areas of aeronautical research and development, to exchange information and ultimately to avoid costly duplication. The Volpe-Jamieson agreement covered aeronautical R&D in telecommunications, navigational aids and air traffic control. In 1980, an Annex to the Volpe-Jamieson agreement was signed, expanding the provisions to encompass all areas of civil aeronautics including airworthiness.

Crashworthiness research and development continues to be undertaken in both countries. Although a great part of the R&D in this area has been focussed on transport category aircraft, increasing public awareness of the significant number of general aviation accidents and ensuing legal actions has raised the profile of the crashworthiness of small aircraft, particularly in the United States.

Concurrent with U.S. efforts, Canadian interest in small aircraft crashworthiness R&D has been re-kindled. Recommendations of the Commission of Inquiry into Aviation Safety and a desire to contribute to U.S./Canada aeronautical R&D have been significant factors. Over 95% of the Canadian fleet falls within the small aircraft category, and increasingly, aircraft accident analyses have pointed to the probability that many of the fatalities and serious injuries experienced could have been prevented through improved crashworthiness.

The objectives of the study were to review the existing status of North American research and development in small aircraft crashworthiness, to identify gaps or areas where further R&D would be beneficial, and to propose R&D program areas which would not only contribute to the enhancement of the safety of small aircraft but also be seen to comprise a meaningful Canadian contribution to joint aeronautical research and development efforts between the United States and Canada.

To achieve these objectives, the report reconstructs the chronology of crashworthiness regulations, provides an outlook on future regulations in this area and outlines the implications of U.S. regulatory developments on Canadian requirements. Small aircraft crashworthiness R&D activities in both the U.S. and Canada are also synthesized with a particular emphasis

placed on recent (post 1980) developments. In addition, existing accident investigation analyses carried out in support of small aircraft crashworthiness R&D are examined.

Since 1985, the extent of ongoing research and development work in the United States has slowed, although it is clear when talking to the principal researchers that much remains to be done. Superficially, the volume of published material suggests it would be difficult to identify gaps in small aircraft crashworthiness R&D, but under scrutiny the gaps began to appear.

Six areas or "gaps" were identified in the course of this study as potential subjects of focus for future R&D. These areas include: research into the applicability of existing crash dynamics data including computer simulation/modelling; systems approach/coordination; retrofit; composites; post-crash survival; and fuel systems (post-crash fire).

From the Canadian perspective, it was concluded that Canada did indeed have an interest in small aircraft crashworthiness R&D and should to the extent possible contribute to international efforts in this area. It was also a concensus that initiatives pursued should, if possible, be in areas of primary "Canadian" interest. Consequently the "gaps" in R&D serve as a basis to re-examine which areas would be of particular value to Canada or areas where there is existing Canadian R&D capability to build on.

The six areas identified as "gaps" (primarily by U.S. researchers) were evaluated in light of the concerns expressed by the government, industry and institutional researchers interviewed in Canada. The factors considered in identifying potential program areas for small aircraft crashworthiness R&D were as follows:

- The general aviation fleet comprises approximately 95% of the total number of aircraft in Canada. Most types are certificated under CAR 3;
- The high cost of replacement aircraft and the financial situtation of private operators and small air carriers makes it highly unlikely that newer aircraft will replace the existing ones in the near future;
- Small aircraft in Canada, more often than in the U.S., operate in sparsely settled regions;
- The conditions in which small aircraft operate in Canada are more severe than those in the U.S.;
- The likelihood of small aircraft accidents occurring in inaccessible areas is higher in Canada than in the U.S.;
- The Canadian Aviation Safety Board (CASB) and other government agencies have, to some degree taken environmental considerations into the development of existing programs, e.g., ELT, R&D;

- Transport Canada as a regulatory body has a requirement to draw upon R&D and engineering work specifically related to special Canadian conditions;
- Pockets of small aircraft crashworthiness R&D expertise exist in Canada; and
- Canada is in a position to facilitate coordination of R&D because it has no vested interest such as a domestic general aviation manufacturing industry, and associated litigation history.

Taking these factors into consideration, two primary potential candidate program areas for Canadian initiative in small aircraft crashworthiness R&D were identified:

1. Retrofit/Partial Retrofit
2. Post-Crash Survival

In addition to these areas, there exists considerable university-based R&D experience in the field of computer simulation. This expertise is primarily housed at the University of Toronto's Institute for Aerospace Studies. A more detailed assessment of this expertise could result in the inclusion of this as an additional potential program area.

The report offers recommendations in three areas - overall "general" recommendations, recommendations with respect to potential program areas, and institutional recommendations. These are as follows:

GENERAL

1. It is recommended that Canada, in the interests of improving safety of general aviation aircraft, increase its contribution to international R&D in the area of small aircraft crashworthiness.

R&D PROGRAM AREAS

1. A general aviation crashworthiness R&D program should be set up in Canada.
2. Retrofit and/or post-crash survival R&D should be the primary focus of work to be undertaken in Canada.
3. A benefit/cost analysis should be carried out to ascertain the impact upon safety of undertaking each R&D program.
4. Prior to program delineation, the FAA and/or other appropriate U.S. agencies should be consulted with respect to their future plans in these areas.

INSTITUTIONAL

1. The National Aeronautical Establishment (NAE) of the National Research Council of Canada (NRC) should become the lead agency for small aircraft crashworthiness R&D.

2. Transport Canada/TDC should sponsor a small aircraft crashworthiness workshop to explore the development of a Canadian crashworthiness R&D program.

3. Transport Canada should sponsor a Standing Committee under the aegis of an NRC Associate Committee to review and coordinate long-term Canadian crashworthiness activities.

4. Transport Canada/TDC should dedicate funds for crashworthiness R&D.

5. The NAE with the assistance of the proposed Crashworthiness R&D Associate Committee should develop a program to monitor the U.S. R&D agencies other than the FAA.

6. Transport Canada should review the Volpe-Jamieson Agreement and its amendments to determine if it is appropriate for a TC-FAA cooperative approach into small aircraft crashworthiness whereby each agency would agree to take a lead role in specific gaps in small aircraft crashworthiness R&D.

7. The CASB should explore with the U.S. National Transportation Safety Board the development of a compatible accident reporting system.

8. Industry cooperation through associations such as the Air Industries Association of Canada (AIAC) should be considered.

RÉSISTANCE À L'ÉCRASEMENT DES PETITS AVIONS

TOUR D'HORIZON DE LA R&D EN AMÉRIQUE DU NORD

SOMMAIRE

Jusqu'en 1970, il n'y avait aucun mécanisme susceptible de coordonner la R&D se faisant au Canada et aux États-Unis en matière d'aéronautique, de sorte qu'il existait une situation de double emploi ou d'absence de collaboration.

L'entente Volpe-Jamieson conclue en 1970 entre la Federal Aviation Administration (FAA) des États-Unis et Transports Canada (TC) visait à: identifier les secteurs de R&D en aéronautique que chaque pays dominait le mieux ou était bien placé pour dominer, procéder à des échanges d'informations et, en fin de compte, éviter le double emploi si coûteux. Cette entente englobait les applications aéronautiques des télécommunications, les aides à la navigation aérienne et le contrôle de la circulation aérienne. En 1980, un avenant a été signé, portant sur la généralisation de l'entente à tous les aspects de l'aéronautique civile, y compris la résistance à l'écrasement.

Bien qu'elle ait surtout été axée sur les aéronefs de transport, il y a depuis peu un certain alignement de la recherche sur la survie des petits avions civils, spécialement aux États-Unis où l'opinion publique est de plus en plus consciente, répercussions juridiques aidant, du nombre croissant d'accidents en aviation générale.

Au Canada, l'intérêt pour la R&D dans ce domaine a été relancé en même temps, principalement sous l'impulsion donnée par la Commission d'enquête sur la sécurité aérienne, suite au désir d'une plus grande participation au programme aéronautique É.-U./Canada. D'autre part, plus de 95 p. 100 des aéronefs canadiens appartiennent à la catégorie des petits avions et, de plus en plus, les enquêtes sur les accidents d'avions montrent que, dans de nombreux cas, les dommages corporels en ayant résulté, fatals ou non, auraient pu être évités si les aéronefs avaient été plus résistants.

La présente étude avait pour but de passer en revue l'état de la R&D sur la résistance des petits avions fabriqués en Amérique du Nord, de mettre en évidence les créneaux oubliés et de cerner les secteurs où une R&D accrue serait bénéfique; également, de proposer un programme de R&D débouchant sur une sécurité accrue tout en constituant une participation intéressante du Canada aux efforts déployés dans le domaine aéronautique des deux côtés de la frontière.

Dans cette optique, le présent rapport fait l'historique de la réglementation applicable, esquisse un aperçu de la réglementation future et souligne les conséquences du resserrement prévu dans la réglementation aux États-Unis sur les conditions minimales exigées au Canada. En outre, il résume les actions de R&D lancées dans ce domaine des deux côtés de la frontière, en insistant sur les plus récentes (à partir de 1980). Enfin, il passe revue les analyses d'accidents d'avions dans le cadre de travaux de R&D en matière de résistance à l'écrasement des petits avions.

L'ampleur de la R&D aux États-Unis n'a cessé de décroître depuis 1985, bien que, de l'avis des principaux établissements de recherche, beaucoup reste encore à faire. La masse des documents de recherche publiés sur ce sujet est telle que, à première vue, on peut avoir l'impression que tout a été couvert dans ce domaine; toutefois, cette impression se dissipe dès que l'analyse se fait plus serrée, laissant apparaître les lacunes.

En effet, notre étude a décelé pas moins de six secteurs ou créneaux pouvant intéresser la R&D. Ce sont: mise à profit des connaissances dans le domaine des forces dynamiques en jeu lors d'un écrasement, par simulation ou modélisation sur ordinateur; approche systémique; rattrapage; matériaux composites; capacité de survie; circuits d'alimentation carburant (prévention d'incendies post-écrasement).

L'étude de la situation canadienne a montré que le Canada avait tout intérêt à approfondir la question de la résistance des petits avions et qu'il devrait participer, dans toute la mesure du possible, aux programmes internationaux de R&D dans ce domaine; elle a également montré que les actions lancées par notre pays devraient, autant que faire se peut, porter sur des points d'intérêt primordialement canadien. Par conséquent, les six créneaux mis en évidence ne constituent qu'un point de départ pour la détermination des secteurs de recherche les plus profitables pour le Canada ou, du moins, de ceux où les compétences canadiennes sont déjà établies.

Les six secteurs ou créneaux qualifiés d'intéressants par des chercheurs surtout américains ont été évalués à la lumière des besoins exprimés par les milieux canadiens autorisés: gouvernement, avionneurs et institutions de recherche. Les facteurs pris en compte ont été les suivants:

- Près de 95 p. 100 des aéronefs immatriculés au Canada appartiennent à la catégorie aviation générale et ont une certification CAR 3.

- Le coût élevé de remplacement conjugué à la situation financière des exploitants privés et des petits transporteurs fait que le rajeunissement du parc dans un avenir rapproché est plus qu'improbable.

- Plus qu'aux États-Unis, les petits avions sont exploités ici dans des régions à faible densité de population.

- Les conditions d'exploitation des petits avions sont plus rigoureuses au Canada qu'aux États-Unis.

- La probabilité qu'un accident de petit avion se produise dans une région reculée est plus élevée ici que là-bas.

- Les organismes canadiens concernés - le Bureau canadien de la sécurité aérienne (BCSA), par exemple - ont tous, dans une certaine mesure, pris en compte les facteurs d'environnement particuliers pour l'élaboration de leur programme respectif. Exemple: les radiobalises de détresse, la R&D, etc.

- À titre d'autorité de réglementation, Transports Canada a le devoir de faire appel à des travaux de R&D ou à des techniques applicables aux conditions particulières du Canada.

- Il existe au Canada des compétences plus ou moins étendues en matière de R&D sur la résistance à l'écrasement des petits avions.
- Le Canada est en bonne position pour agir à titre de coordonnateur de la R&D en ce domaine du fait qu'il ne compte aucun avionneur exploitant le créneau des petits avions et que les litiges associés à cette fabrication sont donc inexistants.

Tout compte fait, les deux secteurs ou créneaux identifiés comme présentant un intérêt réel pour le Canada ont été les suivants:

1. Rattrapage total ou partiel.
2. Capacité de survie.

De plus, il existe dans les universités canadiennes de grandes compétences reliées au domaine de la simulation sur ordinateur, et notamment à l'Institute for Aerospace Studies de l'Université de Toronto. Une analyse approfondie de ces compétences pourrait déboucher sur la décision de créer un autre secteur de R&D axé justement sur la simulation par ordinateur.

Les recommandations formulées dans le rapport sont de trois ordres distincts: généralités, programmes de R&D et établissements de recherche. Elles préconisent que:

GÉNÉRALITÉS

1. Le Canada, dans l'intérêt d'une sécurité accrue de l'aviation générale, intensifie sa participation aux programmes internationaux de R&D dans le domaine concerné.

PROGRAMMES DE R&D

1. Le Canada lance un programme de R&D sur la résistance à l'écrasement des petits avions.
2. Un programme de R&D soit lancé sur ces deux créneaux particuliers que sont le rattrapage et la capacité de survie.
3. Une étude soit lancée sur le rapport avantages-coût de ces deux programmes et sur leur impact en matière de sécurité accrue.
4. Avant de définir ces deux programmes, la FAA et les autres organismes réglementaires des États-Unis soient consultés quant à leurs intentions futures dans les créneaux concernés.

ÉTABLISSEMENTS DE RECHERCHE

1. L'Établissement aéronautique national (EAN) du Conseil national de recherches (CNR) devienne le chef de file des établissements faisant de la R&D dans le domaine de la résistance à l'écrasement des petits avions.

2. Transports Canada et le Centre de développement des transports organisent un atelier où pourra être débattue l'orientation à donner au programme de R&D dans ce domaine.

3. Transports Canada mette sur pied un comité permanent placé sous l'égide d'un comité associé du CNR et chargé d'examiner et de coordonner les actions à long terme dans ce domaine au Canada.

4. Transports Canada et le Centre de développement des transports consentent des fonds à ce programme.

5. L'EAN, avec la collaboration du comité associé proposé, étudie un programme de suivi des actions de R&D lancées aux États-Unis par des organismes autres que la FAA.

6. Transports Canada réexamine l'entente Volpe-Jamieson ainsi que ses avenants afin de déterminer si elle convient à une coopération TC-FAA où ces deux parties se partageraient les créneaux de R&D définis, chacune selon ses compétences propres.

7. Le BCSA étudie avec son homologue américain, le U.S. National Transportation Safety Board, la possibilité d'adopter une procédure de compte rendu d'accident qui soit compatible.

8. La coopération par l'entremise d'associations aéronautiques, comme l'Association des industries aérospatiales du Canada, soit envisagée.

Small Aircraft Crashworthiness
Volume II
Reference Data Base, Program and User Guide

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APPENDIX A: Reference Bibliography
APPENDIX B: Program Disc

1. INTRODUCTION

This volume constitutes the reference bibliography, database program and user guide component of the study entitled "An Overview of Research and Development in Small Aircraft Crashworthiness". In carrying out the review of regulatory developments and crashworthiness R&D activities in the United States and Canada, an extensive list of reference material (published and unpublished) was compiled from existing technical data bases and personal interviews.

Many aspects of small aircraft crashworthiness are technical in nature, and the subject matter in its entirety encompasses a reference base which spans many related disciplines. For example, relevant work can be found under headings of regulatory developments, accident investigation data, automotive R&D, large aircraft and rotary wing R&D, research and development in new materials (composites) and medical research to mention a few. In carrying out the background work for this study an attempt has been made to assemble all relevant reference material relating to small aircraft crashworthiness in one place and to make it easily accessible.

Over thirteen hundred references have been compiled in support of this study. The numbers are so large and the subject matter so diverse that the bibliography was compiled using a data base program. The articles referenced have been coded by subject matter using the following key words:

- Fuselage Design/Structure
- Cockpit/Cabin Design/Structure
- Seats
- Harnesses/Restraints
- Post Crash Fire
- Medical
- Regulations
- Crash Acceleration Environment
- New Materials
- General

The coding allows the researcher to access relevant reference material for his/her requirements. These references are also coded and are accessible by author, date, title, source and country. A hard copy of all entries is presented in bibliographical format in Appendix A.

2. PROGRAM OVERVIEW

Figure 1 represents a flow diagram of user activities offered by the Crashworthiness Bibliography Database software. Once logged in and executing the software you will be presented with a SEARCH MENU which enables you to search the entire database using the following variables:

- Author
- Keyword
- Country, or
- Date

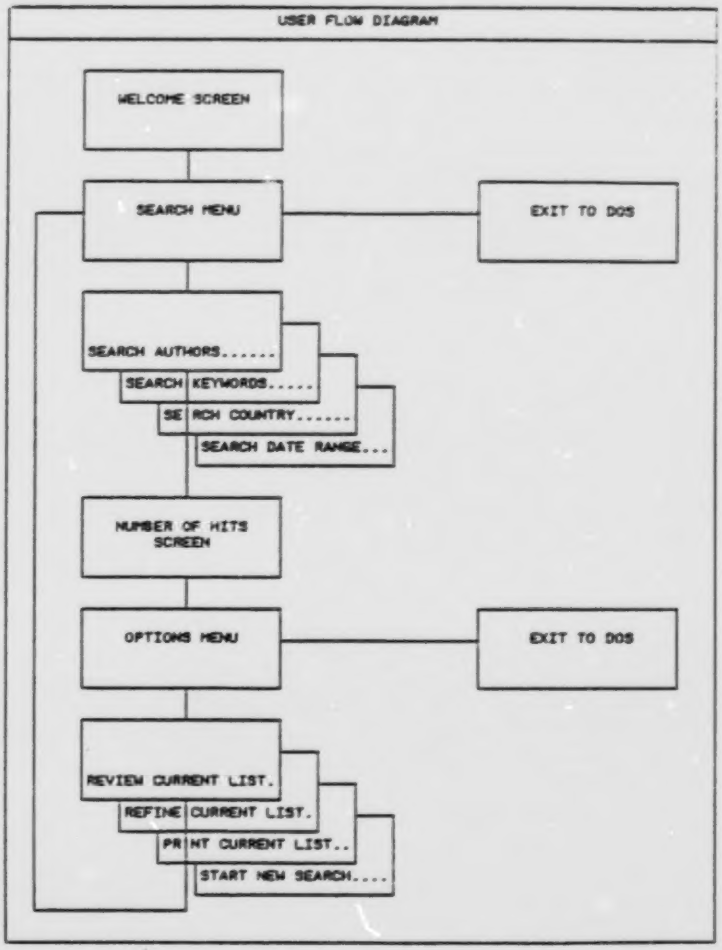

USER FLOW DIAGRAM
WELCOME SCREEN
SEARCH MENU
EXIT TO DOS
SEARCH AUTHORS......
SEARCH KEYWORDS.....
SEARCH COUNTRY......
SEARCH DATE RANGE...
NUMBER OF HITS SCREEN
OPTIONS MENU
EXIT TO DOS
REVIEW CURRENT LIST.
REFINE CURRENT LIST.
PRINT CURRENT LIST..
START NEW SEARCH....

Figure 1. Flow Diagram Of User Activities Available

Once you have executed the search key of interest, you are presented with a HITS screen displaying the actual number of references in your current list, followed by an OPTIONS MENU. The options menu enables you to execute the following:

- view the current list;
- refine the current list;
- print the current list; or
- start a new search.

The remaining sections of this guide are dedicated to the execution of the choices available to the user from the SEARCH MENU and the OPTIONS MENU.

3. INSTALLATION AND EXECUTION

Installation

The CRASHLIB program is designed to run on an IBM/XT compatible computer with a hand drive. The program is written in Clipper and accesses dBase III+ databases. To facilitate search printouts, the printer being used must be set to "compressed print". The files contained on the two discs supplier are:

CRASHLIB.EXE
CRASHBAS.DBF
OLDBASE.DBF
NEWBASE.DBF
TEMPBASE.DBF
TEMPNDX.NTX

Simply create a directory called CRASH and copy all files from both floppies to this directory on the hard disk by typing this DOS command:

```
C:\> mkdir CRASH
```

Insert CRASHWORTHINESS LIBRARY DATABASE SOFTWARE, PROGRAM DISC #1 and type:

```
C:\> copy A:*.*  C:\>CRASH
```

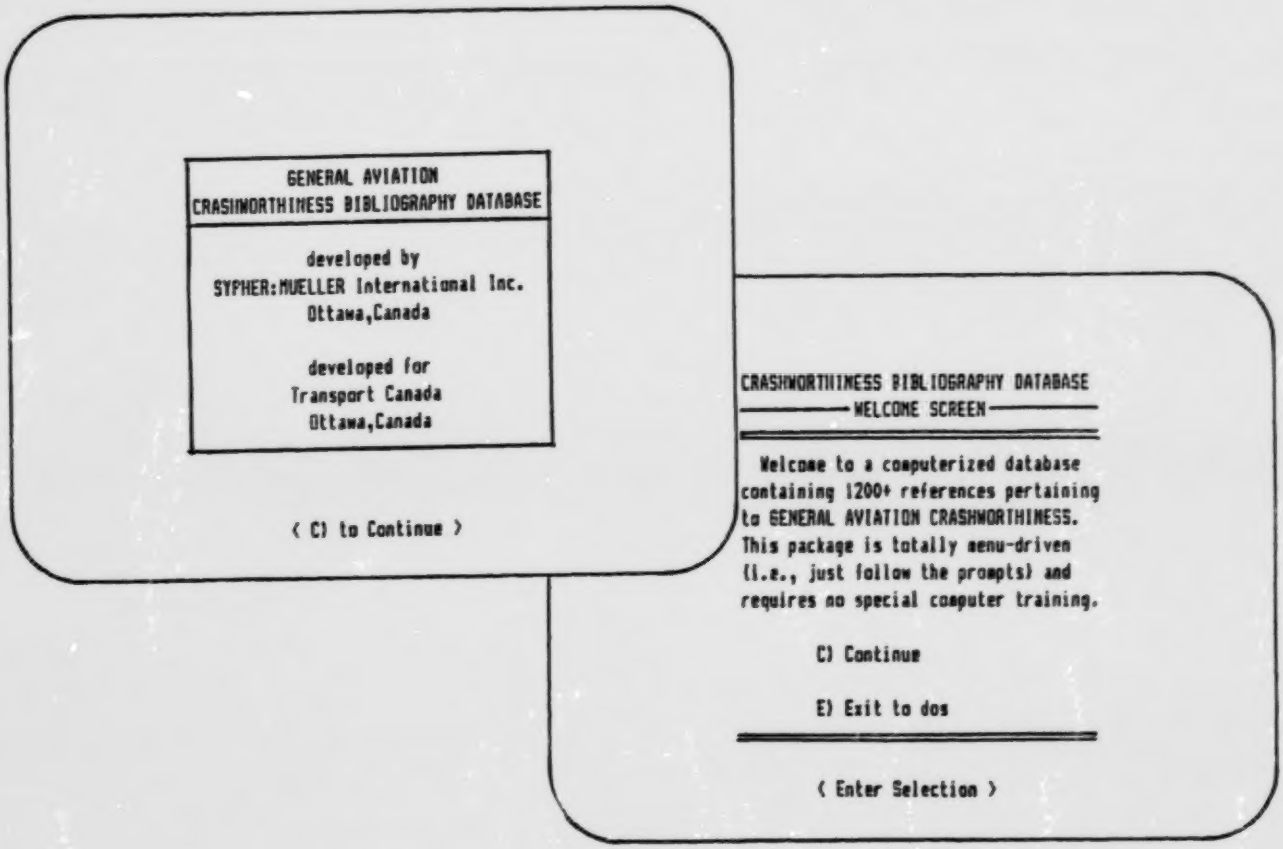
Repeat the copy command for PROGRAM DISC #2.

Execution

To initiate the CRASHLIB program switch to the C:\ CRASH > directory on the hard disc and type CRASHLIB. The program is now executing and will lead you though the menus.

4. SEARCH MENU

After booting up the system, changing to the directory C:\ CRASH and initiating the Crashworthiness Bibliography Database Library software (CRASHLIB), two screens will appear; one screen credits SYPHER:MUELLER International as the developer of the software and Transport Canada as the sponsoring agency, and the other screen describes the subject and size of the database.



GENERAL AVIATION
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developed by
SYPHER:MUELLER International Inc.
Ottawa,Canada

developed for
Transport Canada
Ottawa,Canada

< C) to Continue >

CRASHWORTHINESS BIBLIOGRAPHY DATABASE
WELCOME SCREEN

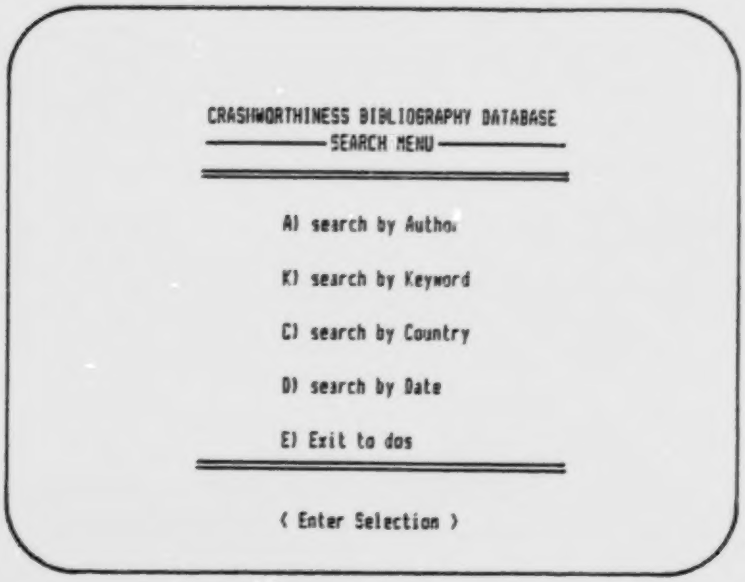
Welcome to a computerized database containing 1200+ references pertaining to GENERAL AVIATION CRASHWORTHINESS. This package is totally menu-driven (i.e., just follow the prompts) and requires no special computer training.

C) Continue

E) Exit to dos

< Enter Selection >

The next step is for the program to initiate the datafile (you will be able to see the records being counted) and finally you will be brought to the SEARCH MENU on the next page.



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CRASHWORTHINESS BIBLIOGRAPHY DATABASE
            SEARCH MENU

         A) search by Autho

         K) search by Keyword

         C) search by Country

         D) search by Date

         E) Exit to dos

         ( Enter Selection )
```

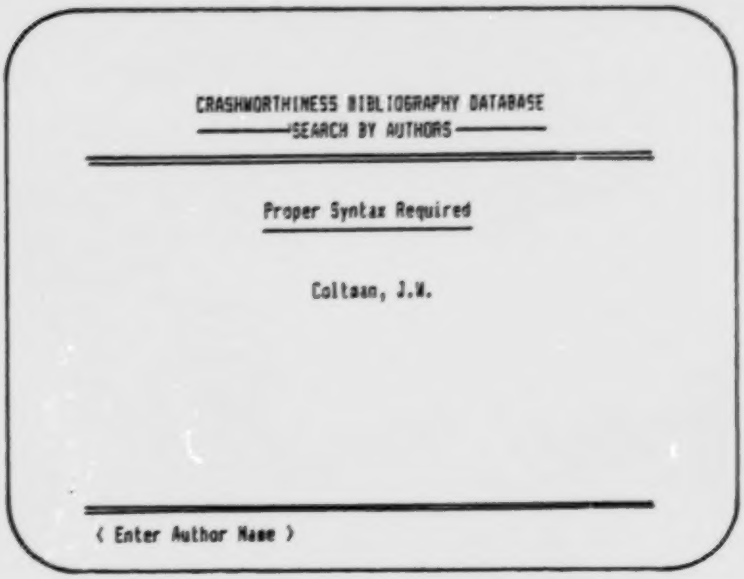
Simply select one of the options presented:

- Depress A to search the database for references written by a specific author.
- Depress K to search the database for references pertaining to one of the ten keywords available.
- Depress C to search the database for references originating from one of the ten countries available.
- Depress D to search the database for references published within a specified data range.

For each option you will be presented with a screen prompting you for the keyword of interest or the date range of interest, for example. You also have the option to exit at this point.

4.1 Search By Author

The search by authors screen appears as below:



CRASHWORTHINESS BIBLIOGRAPHY DATABASE

SEARCH BY AUTHORS

Proper Syntax Required

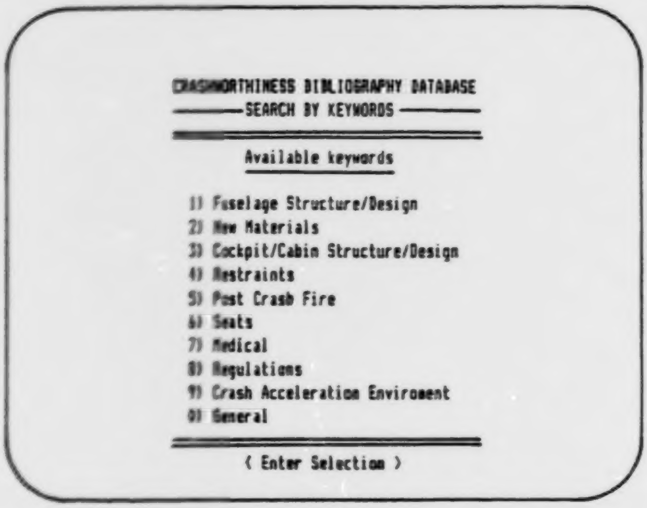
Coltman, J.W.

< Enter Author Name >

Just enter an author's name exactly as shown (i.e., a space after the comma, no spaces between initials and capitals where shown). Once you've pressed the carriage return you will see the program count down the number of records to search before completion. This is the slowest of the searches as the program has to search three fields per database record (three authors are allowed for each reference entry). An information screen will appear next showing you the number of "hits" you achieved with your search term.

4.2 Search By Keyword

The search by keywords screen appears as follows:



```
CRASHWORTHINESS BIBLIOGRAPHY DATABASE
——————SEARCH BY KEYWORDS——————

        Available keywords

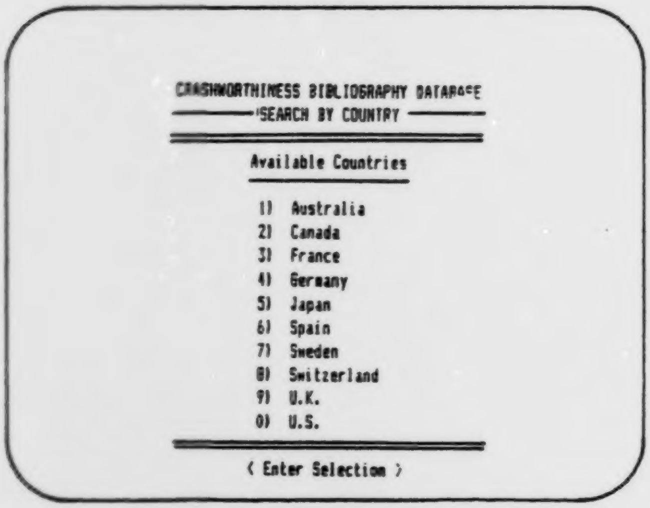
 1) Fuselage Structure/Design
 2) New Materials
 3) Cockpit/Cabin Structure/Design
 4) Restraints
 5) Post Crash Fire
 6) Seats
 7) Medical
 8) Regulations
 9) Crash Acceleration Enviroment
 0) General

         ( Enter Selection )
```

To search the database for references pertaining to any one of these keywords, select the number associated with each. Again, the program will count down the records in the database still to search and follow-up with the "hits" screen showing the number of references in the current list.

4.3 Search By Country

The search by country screen is shown as follows:



```
CRASHWORTHINESS BIBLIOGRAPHY DATABASE
——————SEARCH BY COUNTRY——————

        Available Countries

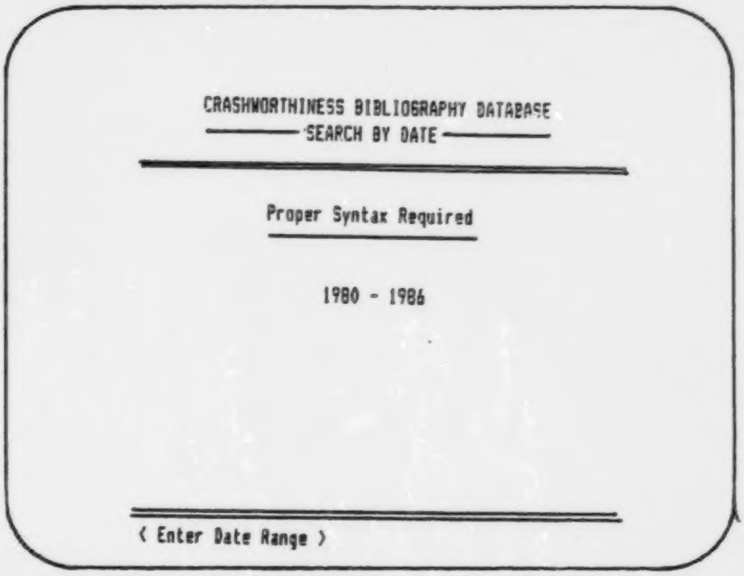
    1)  Australia
    2)  Canada
    3)  France
    4)  Germany
    5)  Japan
    6)  Spain
    7)  Sweden
    8)  Switzerland
    9)  U.K.
    0)  U.S.

         ( Enter Selection )
```

To search the contents of the database for all references published in one of the countries listed, simply depress the number associated with each. As with the previous options, the program will count down the records in the database still to search and follow-up with a screen displaying how many references are in your current list.

4.4 Search By Date

The last search option screen, search by date, is shown as follows:



CRASHWORTHINESS BIBLIOGRAPHY DATABASE
SEARCH BY DATE

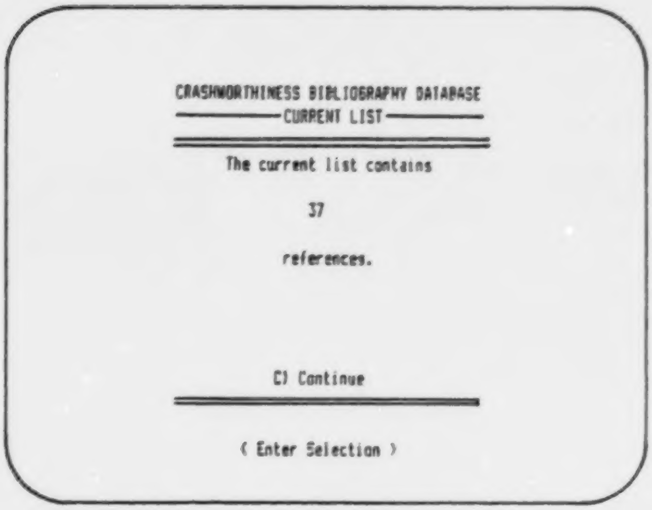
Proper Syntax Required

1980 - 1986

< Enter Date Range >

To restrict the references to a specific data range enter the earliest and latest years of interest as shown on the screen. Again, "records still to search" count-down will occur followed by a screen informing the user of the number of references that met the date range requirements.

ALL SEARCH MENU options lead to the screen informing you (the user) of the number of references remaining in the current list.



CRASHWORTHINESS BIBLIOGRAPHY DATABASE
CURRENT LIST

The current list contains

37

references.

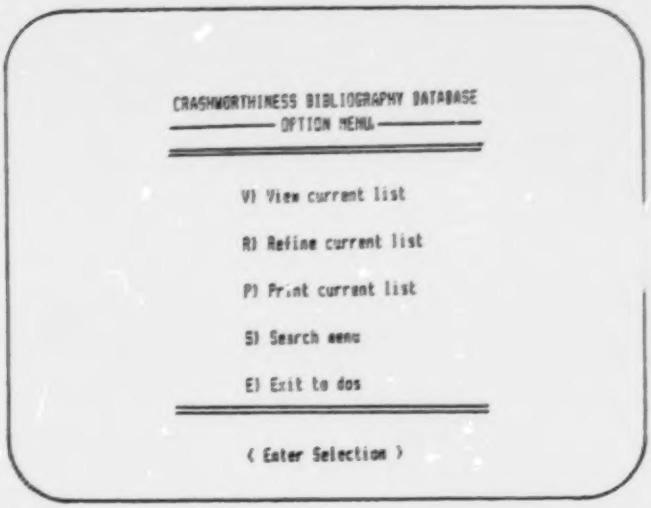
C) Continue

(Enter Selection)

The OPTIONS MENU enables you to view, refine or print your current list or simply start another search.

5. OPTIONS MENU

The OPTIONS MENU, as it appears below, enables the user to work with the references presently in the current list.



```
CRASHWORTHINESS BIBLIOGRAPHY DATABASE
----------- OPTION MENU -----------
===================================

        V) View current list

        R) Refine current list

        P) Print current list

        S) Search menu

        E) Exit to dos
===================================

        ( Enter Selection )
```

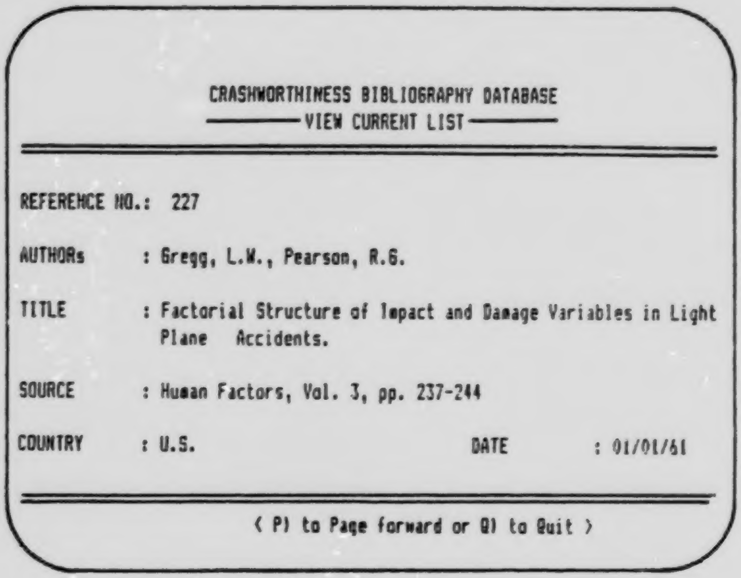
Simply select one of the options presented:

- Depress V to page through each reference in your current list.
- Depress R to refine your search by using one of the Boolean operators (AND, OR, or NOT) to link your old current list of references with a new search term.
- Depress P to print out in hardcopy the current list of references.
- Depress S to return to the SEARCH MENU and start a new search sequence.

You also have the option to Exit at this point.

5.1 View Current List

Selecting V produces a screen with the following information:



```
            CRASHWORTHINESS BIBLIOGRAPHY DATABASE
            ——————— VIEW CURRENT LIST ———————

REFERENCE NO.:  227

AUTHORs       : Gregg, L.W., Pearson, R.G.

TITLE         : Factorial Structure of Impact and Damage Variables in Light
                Plane   Accidents.

SOURCE        : Human Factors, Vol. 3, pp. 237-244

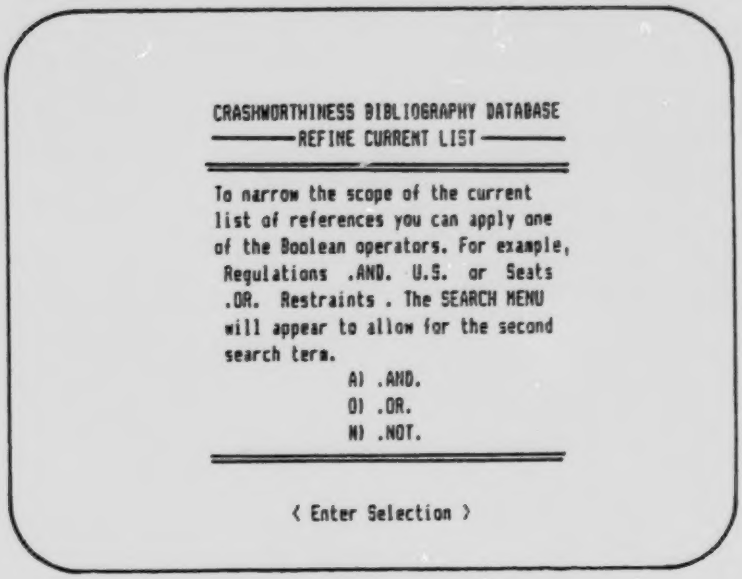
COUNTRY       : U.S.                       DATE        : 01/01/61

              ( P) to Page forward or Q) to Quit )
```

Author(s), title, source, country and date for each reference in the current list.

5.2 Refine Current List

Selecting R produces the following screen.



```
              CRASHWORTHINESS BIBLIOGRAPHY DATABASE
              ———————— REFINE CURRENT LIST ————————
              ═════════════════════════════════════
              To narrow the scope of the current
              list of references you can apply one
              of the Boolean operators. For example,
               Regulations  .AND.  U.S.  or  Seats
               .OR.  Restraints . The SEARCH MENU
               will appear to allow for the second
               search term.
                            A) .AND.
                            O) .OR.
                            N) .NOT.
              ═════════════════════════════════════

                        < Enter Selection >
```

The refined current list gives you the flexibility to narrow the scope of your search by using any one of the three Boolean operators: AND, OR or NOT. For example, if your previous search key was the keyword "New Materials" and resulted in a current list of 370 references, your next search instruction would be "AND" a date range of "1984-1986". This second iteration might result in only 20 references. At this point you might want to review the contents of each bibliography entry as the current list is now reduced in size and scope.

5.3 Print Current List

Selecting P simply produces a listing of references in the current list. This print out appears as follows:

```
                                                        page    1

                    CRASHWORTHINES BIBLIOGRAPHY DATABASE
       -----------------------------PRINTOUT-----------------------------


REFERENCE No:   660
AUTHORs     :  Williams, M.S., Fasanella, E.L.
TITLE       :  Crash Tests of Four Low-Wing Twin-Engined Airplanes With
               Truss-     Reinforced Fuselage Structure.
SOURCE      :  NASA Technical Paper 2070
COUNTRY     :  U.S.
DATE        :  09/01/82


REFERENCE No:   680
AUTHORs     :  Castle, C.B., Alfaro-Bou, E.
TITLE       :  Crash Tests of Three Identical Low-Wing Single-Engine
               Airplanes.
SOURCE      :  NASA TP-2190
COUNTRY     :  U.S.
DATE        :  01/01/83


REFERENCE No:   913
AUTHORs     :  Chronkhite, J., Berry, V.
TITLE       :  Crashworthy Airframe Design Concepts Fabrication and
               Testing
SOURCE      :  NASA CR 3603
COUNTRY     :  U.S.
DATE        :  09/01/82


REFERENCE No:   924
AUTHORs     :  Thomson, R.G., Caiafa, C.
TITLE       :  Structural Response of Transport Airplanes in Crash
               Situations
SOURCE      :  NASA TM 85654
COUNTRY     :  U.S.
DATE        :  06/01/83
```

5.4 Search Menu

Depressing S brings you back to the beginning of the program. The datafile is re-initialized and you can now inititate a new search term.

6. PROGRAM CONCERNS

The General Aviation Crashworthiness Bibliography Database Software is totally menu driven, therefore, you are in the guidance of the menu options at all times. All user data entry points are designed such that the screen will re-appear should you input an unexpected character.

Warning should be given that new searches and database initializations are time consuming. With the database at almost 1400 references, the database initialization consumes about 40 seconds and a search consumes approximately 45 seconds. (These time checks were run on an 10 MHz Epson Equity I with a hard drive). However, a second iteration through the REFINE option takes a fraction of the time as the program is now working with a fraction of the initial 1400 references.

APPENDIX A

Reference Bibliography

CRASHBASE BIBLIOGRAPHY DATABASE PRINTOUT

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11) "6-Year-Old Anthropomorphic Test Dummy ", Humanoid Systems Catalog, Model 572-6c, pp. 9-10, California, U.S., January, 1981

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13) "72 Stat. 49 U.S.C. 1301-1542, Pub. L. 85-726, Title XIV, 1401.", Federal Aviation Act of 1958, U.S., August, 1958

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APPENDIX B

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